

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau



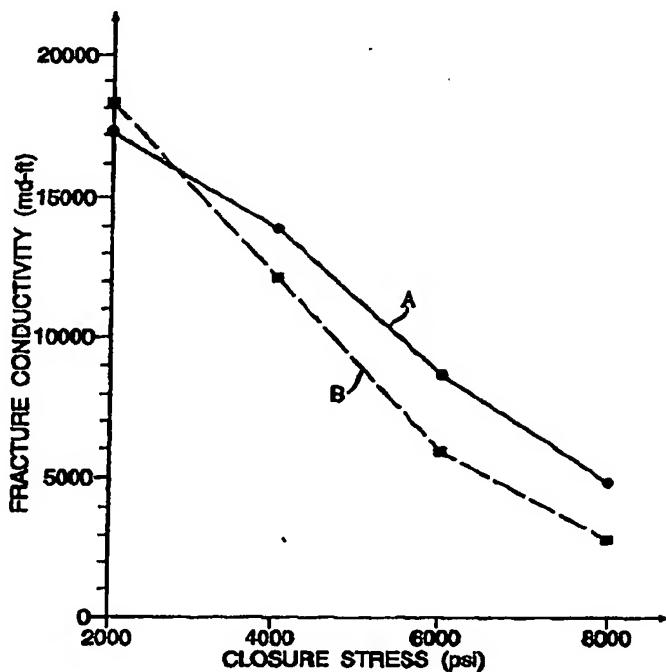
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : E21B 43/267, 33/138		A1	(11) International Publication Number: WO 99/54592
			(43) International Publication Date: 28 October 1999 (28.10.99)
(21) International Application Number: PCT/GB99/01125		(81) Designated States: AU, BR, CA, GB, MX, NO, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).	
(22) International Filing Date: 13 April 1999 (13.04.99)		Published <i>With international search report.</i>	
(30) Priority Data: 9808490.8 22 April 1998 (22.04.98) GB			
(71) Applicant (<i>for all designated States except US</i>): AEA TECHNOLOGY PLC [GB/GB]; 329 Harwell, Didcot, Oxfordshire OX11 0RA (GB).			
(72) Inventor; and			
(75) Inventor/Applicant (<i>for US only</i>): WEBB, Philip, John, Charles [GB/GB]; Ault More, Stobhall, Maryculter, Aberdeenshire AB12 5GJ (GB).			
(74) Agents: MANSFIELD, Peter, Turquand et al.; AEA Technology plc, Patents Dept., 329 Harwell, Didcot, Oxfordshire OX11 0RA (GB).			

(54) Title: WELL TREATMENT FOR WATER RESTRICTION

(57) Abstract

An oil or gas well is treated to reduce the proportion of water produced by the well, by subjecting the well to a fracture treatment with proppant particles whose conductivity decreases when they are contacted by water. The particles may be of a ceramic material, and may be coated on their external surfaces with a water-soluble chemical; if the proppant particles are porous, they may also be impregnated with the water-soluble chemical. When contacted with water the permeability of a bed of such particles decreases, because the particles become slightly smaller and/or weaker. The chemical might be a water-soluble polymer or a scale inhibitor.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Benin	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Beira	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NB	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KR	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LJ	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		

- 1 -

Well Treatment for Water Restriction

This invention relates to a method for treating an oil or gas well so as to restrict the inflow of water.

5

Oil and gas wells extend through subterranean formations, some of which are fluid permeable and contain oil or gas. The oil or gas-containing formation may also contain water, or in some cases water may be injected 10 into such a formation by a well operator to displace other fluids. Consequently water may flow into the well along with the oil or gas, the proportion of water varying through the formation. Where a formation is insufficiently permeable it is known to enhance its 15 permeability by subjecting it to a fracturing treatment and injecting proppant particles. This will increase the permeability of the formation to any fluids present.

According to the present invention there is provided 20 a method of treating an oil or gas well so as to reduce the proportion of water produced by the well, the method comprising subjecting the well to a fracture treatment with proppant particles whose conductivity decreases when they are contacted by water.

25

The proppant particles may be coated on their external surfaces with a water-soluble chemical such as a scale inhibitor. In this case the particles may be either porous or non-porous. Alternatively the proppant 30 particles might be porous, impregnated with a water-soluble chemical, such that the proppant particles are progressively crushed as the chemical is dissolved. The particles in either case may be of a ceramic material, and are preferably of size in the range 0.3 mm to 5 mm, 35 more preferably between 0.5 mm and 2.0 mm, for example

- 2 -

about 0.5 mm or about 1.0 mm. It is usually desirable to have all particles of substantially the same size.

It will be appreciated that the water-soluble
5 chemical may be one which has no appreciable effect on any chemical processes within any well. Alternatively it may be a chemical which would suppress a deleterious process (such as corrosion or scale formation), but be used in a well in which that deleterious process is not
10 occurring anyway - i.e. it has no appreciable effect on any chemical processes occurring in that well.

The invention will now be further described by way of example only, and with reference to the accompanying
15 drawing, which shows graphically the variation of fracture conductivity with closure stress for two different types of proppant particle.

When it is desired to enhance the permeability of a
20 formation comprising oil-bearing strata in the vicinity of an oil well, it is known to inject fluid into the well such that the pressure at the depth of those strata is sufficient to cause fracturing of the rocks of the strata. The fluid injected into the rocks may contain a
25 dissolved polymer which may be cross-linked to form a gel (so it is of high viscosity), and contains proppant particles which are carried into the fractures by the injected fluid. When the pressure is reduced the particles prevent the fractures closing. Typically the
30 fractures extend over 20 m out from the well bore, often in excess of 100 m, and the proppant particles will be distributed throughout the length of every fracture.

This embodiment of the invention uses, as the
35 proppant particles, porous alumino-silicate ceramic beads of porosity about 6 percent and of size 16/20 mesh (0.85

- 3 -

- 1.2 mm). The beads are coated and impregnated with a scale inhibitor chemical in solid form. This may be done by substantially the same procedure as that described in GB 2 298 440 A, as follows:

5

(i) concentrated aqueous solution of scale inhibitor is made from a commercially-available diethylene-triamine penta-(methylenephosphonic acid)-based scale inhibitor (initially about 25 percent active material), by first adding to this inhibitor 5000 to 25,000 ppm cations (calcium and magnesium) added as chlorides, preferably 12,000 to 25,000 ppm, and then distilling under vacuum to about half the initial volume. The pH is adjusted to a value in the range pH 6.0 to pH 15 11.0 by acting concentrated sodium hydroxide, preferably to pH 10.

20 (ii) the ceramic beads are placed in a pressure vessel, and the vessel evacuated to about 0.1 mbar (10 Pa) absolute to ensure that no air or vapours remain in the pores. The vessel is then filled under vacuum with the concentrated inhibitor. After quarter of an hour the vacuum is released, the vessel drained, and the wet beads removed.

25

(iii) the wet beads are then dried in an oven or a fluidised bed, so that they contain the scale inhibitor in a solid form.

30

If such beads are used as proppants then, in those parts of the fracture in which water flows, the permeability will decrease, because the water will dissolve the scale inhibitor from the surface of the beads. This decrease in permeability is illustrated in 35 the figure, to which reference is now made. This shows graphically the fracture conductivity when using such

- 4 -

beads containing solid scale inhibitor (graph A) and the fracture conductivity if all the scale inhibitor has dissolved from such beads (graph B). The fracture conductivity values are given in millidarcy feet (1 md ft = $0.3 \times 10^{-15} \text{ m}^3$) and the closure stresses in psi (1000 psi = 6.8 MPa). In both cases the conductivity decreases at higher closure stresses, but for all closure stresses above about 3000 psi the fracture conductivity is noticeably less once the inhibitor has dissolved (graph 10 B).

The decrease in fluid conductivity as the scale inhibitor dissolves is the result of two mechanisms. Firstly, the dissolution of the scale inhibitor from the external surface of the beads reduces their diameter, so lowering the conductivity. Secondly, the dissolution of the scale inhibitor from the surface and the pores weakens the beads so they are less able to withstand the closure stress, and they generate fines, which also lowers the fluid conductivity. For example experimental tests at a closure stress of 5000 psi found that the beads containing scale inhibitor generated about 10 percent fines, whereas the beads containing no scale inhibitor generated 28 percent fines.

25

It will be appreciated that the process of the invention may be performed using beads which differ from those described above. For example the ceramic beads might be substantially non-porous, with only an external coating of the solid scale inhibitor. The beads might be impregnated and coated with a different scale inhibitor, or indeed with any water-soluble chemical, for example a water-soluble polymer. It will also be understood that the size of the beads must be selected so as to ensure 30 the beads are sufficiently strong to withstand the closure stresses in the fracture, and to provide a 35

- 5 -

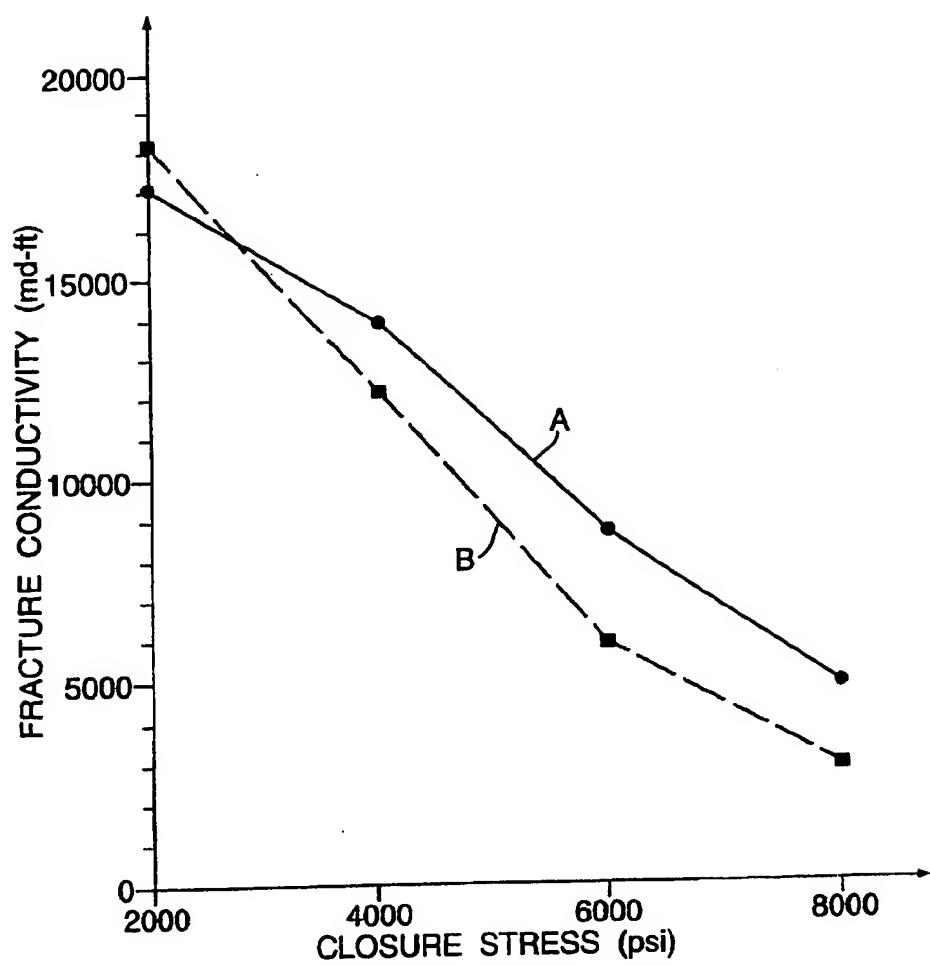
significant contrast in flow capacity between the fracture and the formation.

- 6 -

Claims

1. A method of treating an oil or gas well so as to reduce the proportion of water produced by the well, the
5 method comprising subjecting the well to a fracture treatment with proppant particles whose conductivity decreases when they are contacted by water.
2. A method as claimed in claim 1 in which the proppant
10 particles are coated on their external surfaces with a water-soluble chemical.
3. A method as claimed in claim 1 or claim 2 in which the proppant particles are porous and are impregnated
15 with a water-soluble chemical.
4. A method as claimed in claim 2 or claim 3 in which the water-soluble chemical is one which has no appreciable effect on any chemical processes within any
20 well.
5. A method as claimed in claim 2 or claim 3 in which the water-soluble chemical is a scale inhibitor.
- 25 6. A method as claimed in any one of the preceding claims in which the particles are of a ceramic material, and are of size in the range 0.3 mm to 5 mm, more preferably between 0.5 mm and 2.0 mm, for example about 0.5 mm or about 1.0 mm.

1/1



INTERNATIONAL SEARCH REPORT

Int'l Application No
PCT/GB 99/01125

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 E21B43/267 E21B33/138

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 193 369 A (EXXON CHEMICAL PATENTS INC) 3 September 1986 see page 2, line 4 - line 32 see page 3, line 17 - page 4, line 16 see page 5, line 22 - page 6, line 16	1-5
X	US 5 422 183 A (A.R.SINCLAIR) 6 June 1995 see column 1, line 12 - line 42	1
X	US 4 518 039 A (J.W.GRAHAM) 21 May 1985 see column 1, line 22 - line 48	1
X	US 5 420 174 A (B.DEWPRASHAD) 30 May 1995 see column 1, line 8 - column 2, line 15	1

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

14 July 1999

Date of mailing of the international search report

21/07/1999

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl.
Fax: (+31-70) 340-3016

Authorized officer

Boulon, A

INTERNATIONAL SEARCH REPORT

Information on patent family members

Int'l	Int'l Application No
PCT/GB 99/01125	

Patent document cited in search report		Publication date		Patent family member(s)	Publication date
EP 193369	A	03-09-1986	US	4670166 A	02-06-1987
			AU	583095 B	20-04-1989
			AU	5409286 A	04-09-1986
			CA	1262507 A	31-10-1989
			US	4738897 A	19-04-1988
US 5422183	A	06-06-1995	US	5597784 A	28-01-1997
US 4518039	A	21-05-1985	US	4553596 A	19-11-1985
			US	4597991 A	01-07-1986
			US	4732920 A	22-03-1988
US 5420174	A	30-05-1995		NONE	